

PROFILE The shipbuilding and ship repair sector⁴ builds and repairs ships, barges, and other large vessels for military and commercial clients. The sector also includes operations that convert or alter ships, as well as facilities that manufacture offshore oil and gas well drilling and production platforms. Most facilities that build ships also have the ability to repair ships, although some smaller yards do only repair work.



Sector At-a-Glance

Number of Facilities:	346 ¹
Value of Contracts:	\$16 billion ²
Number of Employees:	92,400 ³

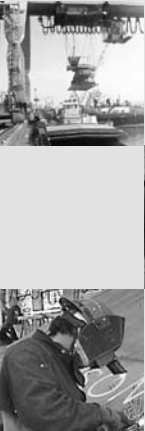
TRENDS Over the past four years, the shipbuilding and ship repair industry has been relatively stable.

- Appropriations for construction of new military ships showed a modest increase (6%) from 2000 to 2006, but declined by 35% over the last year.⁵
- Between 2000 and 2004, employment within the sector fell from 102,000 to 92,400.⁶
- The U.S. now has less than a 1% share of the world's new construction market for commercial vessels of more than 1,000 gross tons, lagging behind the world's shipbuilding leaders such as South Korea, Japan, China, Germany, Italy, and Poland.⁷

In the fall of 2005, hurricanes hit Gulf Coast shipyards hard. Time will tell whether these facilities will fully recover from the damage the storms inflicted.

KEY ENVIRONMENTAL OPPORTUNITIES

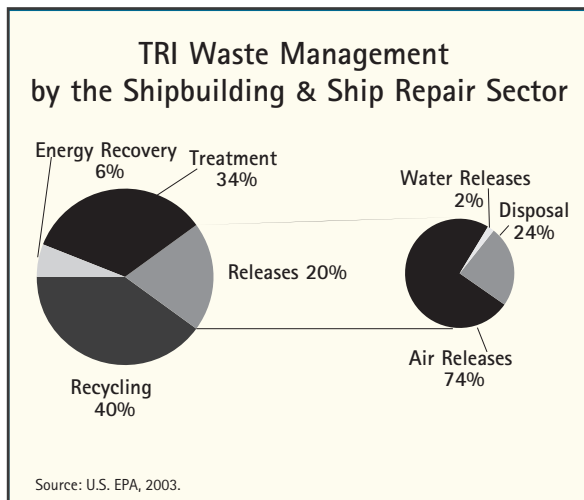
For the shipbuilding and ship repair sector, the greatest opportunities for environmental improvement are in managing and minimizing toxics and waste, reducing air emissions, and improving water quality.



MANAGING AND MINIMIZING TOXICS

Given the diversity of their industrial processes, shipbuilding and ship repair facilities use a variety of chemicals and report on the release and management of many of those materials through EPA's Toxics Release Inventory (TRI).

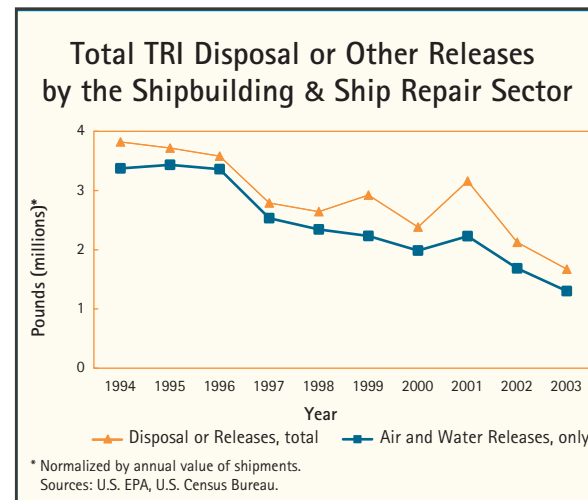
In 2003, 41 facilities in the sector reported 10.5 million pounds of chemicals released (including disposal) or otherwise managed through treatment, energy recovery, or recycling. Of this quantity, 80% was managed, while the remaining 20% was disposed or released to the environment, as shown in the *TRI Waste Management* pie chart. Of those chemicals disposed or released to the environment, 24% were disposed and 76% were released into air or water.



As shown in the *Total TRI Disposal or Other Releases* line graph, the annual normalized quantity of chemicals disposed or released by this sector decreased by more than half (58%) from 1994 to 2003, with one-third of this decline occurring between 2000 and 2003. From 2000 to 2003, there was a similar decline of 37% in the sector's normalized quantity of chemicals released to air and water.

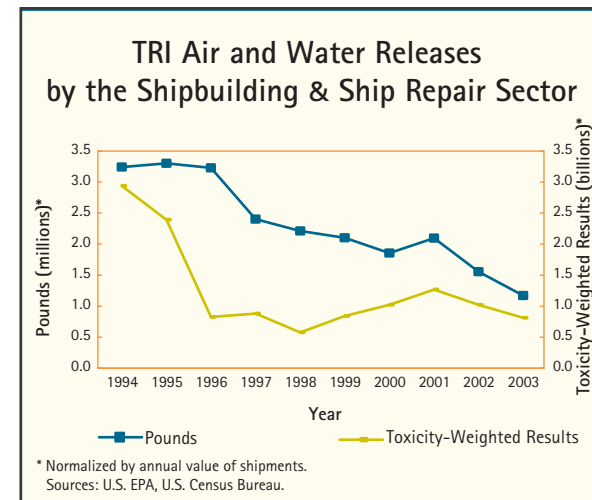
In 2003, the chemicals disposed or released by the sector were dominated by n-butyl alcohol and xylene, which accounted for 42% of the total pounds. Zinc, copper, and 1,2,4-trimethylbenzene accounted for another 26% of the sector's total.⁸

Data from TRI allow comparisons of the total quantities of a sector's reported chemical releases across years, as presented below. However, this



comparison does not take into account the relative toxicity of each chemical. Chemicals vary greatly in toxicity, meaning they differ in how harmful they can be to human health. To account for differences in toxicities, each chemical can be weighted by a relative toxicity weight using EPA's Risk-Screening Environmental Indicators (RSEI) model.

The *TRI Air and Water Releases* line graph presents trends for the sector's air and water releases in both reported pounds and toxicity-weighted results. When weighted for toxicity, the sector's normalized air and water releases show a 73% decline from 1994 to 2003, with little overall change from 2000 to 2003, despite an increase in 2001. The spike in 2001 is attributable to an increase in manganese releases to air, with one facility accounting for 68% of those releases.



The table below presents a list of the chemicals released that accounted for 90% of the sector's total toxicity-weighted releases to air and water in 2003. More than 99% of the sector's toxicity-weighted results were attributable to air releases, while discharges to water accounted for less than 1%. Therefore, reducing air emissions of these chemicals presents the greatest opportunity for the sector to make progress in reducing the toxicity of its releases.

Top TRI Chemicals Based on Toxicity-Weighted Results	
AIR RELEASES (99%)	WATER RELEASES (<1%)
Manganese	Copper
Chromium	Lead
Nickel	
Sulfuric Acid	
Source: U.S. EPA	

In 2003, toxicity-weighted results were driven by manganese, nickel, and chromium. In recent years, normalized manganese and chromium releases to air fluctuated but resulted in little overall change between 1999 and 2003. During this time period, nickel releases increased steadily, more than tripling. One facility accounted for 69% of the industry's nickel emissions in 2003.

EPA's RSEI model conservatively assumes that chemicals are released in the form associated with the highest toxicity weight. With respect to chromium releases to air and water, therefore, the model assumes that 100% of these emissions are hexavalent chromium (the most toxic form, with significantly higher oral and inhalation toxicity weights than trivalent chromium).⁹ Research indicates that the hexavalent form of chromium does not constitute a majority of total chromium releases by shipyards. Thus, RSEI analyses overestimate the relative harmfulness of chromium in the sector.¹⁰

REDUCING AIR EMISSIONS Most large ships are built of steel and must be periodically cleaned and coated in order to preserve the steel and provide specific performance characteristics to the surface. The shipbuilding and ship repair sector releases particulate matter (PM), volatile organic compounds (VOCs), and air toxics during surface preparation and the application of paint and coatings. Although emissions of VOCs and air toxics during these processes are largely captured in the TRI air releases discussed above, this section takes a closer look at PM and these chemical categories.



Particulate Matter Surface preparation is critical to the coating life cycle, since it provides both the physical and chemical requirements for long-term coating adhesion. To prepare surfaces for coating applications, shipyards predominantly use a dry-abrasive blasting process. This dry-abrasive blasting is typically performed outdoors, as the sheer size of a ship makes enclosure difficult and expensive.

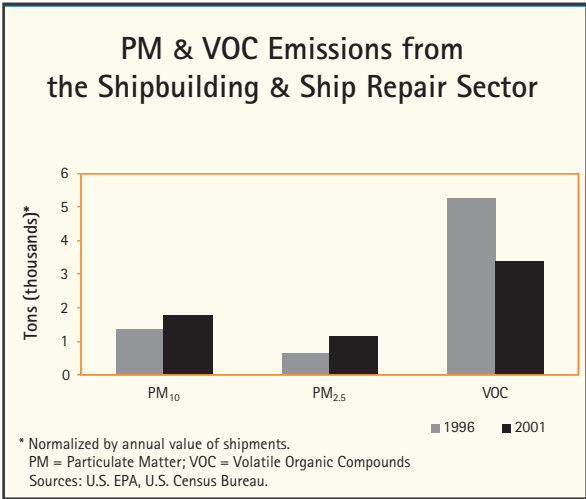
The blasting operation generates PM emissions from both the breakup of the abrasive material and the removal of the existing coating. Over the past 10 years, shipyards have developed several methods to reduce PM emissions to the environment, including:

- Temporary containment of blasting operations;
- Material substitutions; and
- Alternative surface preparation technologies.

Early attempts at temporary containment consisted of hanging curtains from scaffolding, wires, dock-arms, and other structures around the ship. Generally, these temporary structures were open at the top and reduced PM emissions by reducing the wind speed in the blasting area. This practice has evolved to include the construction of temporary shrink-wrap enclosures of entire ships in drydock.

EPA's National Emissions Inventory (NEI) estimates that, in 2001, the sector released 1,963 tons of PM₁₀ and 1,257 tons of PM_{2.5}.

As shown in the *PM & VOC Emissions* bar chart, between 1996 and 2001, normalized PM₁₀ and PM_{2.5} emissions from this sector increased by approximately 31% and 74%, respectively.¹¹ However, these emissions estimates may not reflect the shipyards' efforts in the last five years to contain PM emissions from abrasive blasting by using shrouds, shrink-wrap, and other forms of containment. In addition, many shipyards have switched blasting materials from coal slag and steel shot to garnet, high-pressure water, and other lower emission technologies. The following case study highlights one shipyard's success in reducing PM emissions by adopting an alternative blasting technology.



Case Study: Ultra-High Pressure Water Blasting at Atlantic Marine In an effort to reduce its PM emissions, Atlantic Marine in Jacksonville, FL, has stopped all open-air abrasive blasting in favor of ultra-high pressure (UHP) water blasting. This technology uses high-pressure streams of water, instead of grit, to remove the coatings from ships. Unlike abrasive blasting, there are no PM emissions from the water stream, and the flakes of paint are larger so they do not end up in the air. Over the last six years, Atlantic Marine has avoided more than 460 tons of PM emissions through the adoption of the UHP technology, as shown in the following table.¹²

PM Emissions Avoided by Atlantic Marine	
YEAR	TONS AVOIDED
1999	32.0
2000	43.1
2001	121.7
2002	83.2
2003	76.0
2004	104.4
Total	460.4



Volatile Organic Compounds & Air Toxics

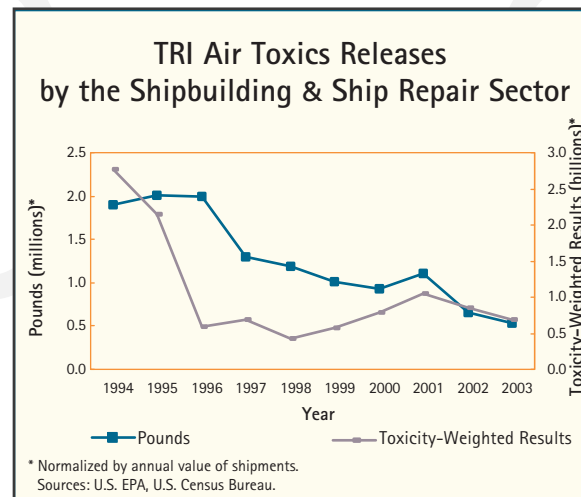
Once the ship's surface is properly prepared, coatings can be applied. The type of coating to be applied (typically down to the level of a specific brand) is specified by the customer (i.e., the ship owner/operator) rather than the shipyard. These coatings may contain chemicals that are released to the environment during application. When coatings are applied indoors, it is possible to utilize pollution control equipment, such as spray booths, to control the release of VOCs and air toxics. At shipyards, however, most coatings are applied outdoors. As a result, VOCs and air toxics may be released into the environment.

EPA's NEI estimates that, in 2001, the sector released 3,333 tons of VOCs. As shown in the *PM & VOC Emissions* bar chart on the previous page, normalized VOC emissions from shipyards declined by 36% between 1996 and 2001.¹³

Air toxics, also called hazardous air pollutants, are a subset of the TRI chemicals presented above. The Clean Air Act designates 188 chemicals (182 of which are included in TRI) that can cause serious health and environmental effects as air toxics. In 2003, 38 facilities in the sector reported air toxics releases of 730,000 pounds.

As shown in the *TRI Air Toxics Releases* line graph, normalized air toxics releases decreased by 72% from 1994 to 2003, with more than one-quarter of this decrease occurring between 2000 and 2003.¹⁴ Toxicity-weighted results for air toxics releases showed a similar decline over the 10-year period.¹⁵

Much of the decline in both VOC and air toxics emissions is due to the reformulation of marine coatings. Coatings manufacturers, working in cooperation with shipyards, have reformulated many coatings to reduce VOC and air toxics content while maintaining or improving the performance characteristics required by customers. Although more viscous and difficult to apply, these low-VOC, high-solids content coatings have become the industry standard due to their excellent performance characteristics.



The following case study highlights one shipyard's success in reducing VOC emissions through product substitution.

Case Study: VOC Emissions Reductions at Electric Boat

In order to lower VOC emissions and eliminate the need for control equipment, Electric Boat in Groton, CT, conducted an exhaustive review of more than 10,000 products listed in its inventory system to identify those materials with VOCs greater than 3.5 pounds per gallon, developed an electronic catalog system to identify specific environmental data and replacements for these materials, and implemented stringent reviews of all new materials for use in production and maintenance work. Additionally, Electric Boat initiated an electronic record system to collect air emissions data associated with boilers and generators. As a result, Electric Boat has replaced more than 100 adhesives, glues, fillers, and sealants with products that do not exceed 3.5 pounds of VOCs per gallon.¹⁶



MANAGING AND MINIMIZING WASTE

EPA hazardous waste data on large quantity generators, as reported in the *National Biennial RCRA Hazardous Waste Report*, indicate that the shipbuilding and ship repair sector accounted for less than 1% of the hazardous waste generated nationally in 2003.

In 2003, 63 facilities in the sector reported 12,000 tons of hazardous waste generated. Half of the sector's waste was generated through wastewater treatment, and another 21% was generated from painting and coating processes. The waste management methods most utilized by this sector were chemical precipitation, fuel blending, and landfill or surface impoundment.

When reporting hazardous wastes to EPA, quantities can be reported as a single waste code (e.g., lead) or as a commingled waste composed of multiple types of wastes. Quantities of a specific waste within the commingled waste are not reported. The shipbuilding and ship repair sector reported 68% of its wastes as individual waste codes. Of the individually reported wastes, the predominant hazardous waste types reported by the sector in 2003 included corrosive waste (6,000 tons), lead (1,000 tons), ignitable waste, and chromium. Additional quantities of these wastes also were reported as part of commingled wastes.¹⁷

Over the past decade, the shipbuilding and ship repair sector has made progress in reducing waste generation and increasing reuse and recycling rates. Improvements in hazardous waste management at shipyards can be attributed to several practices, including:

- Development of improved coating application technologies, such as in-line plural component mixers that only mix the amount of coating necessary, as it is required, to avoid the waste of excess paint;
- Use of paint waste for fuel blending, rather than solidifying it for land disposal; and
- Reclamation of spent solvents from spray paint equipment.

IMPROVING WATER QUALITY Releases of chemicals into water account for a small fraction of the TRI toxicity-weighted results for this sector. However, pollutants generated by shipyards can be released into the environment through stormwater runoff.

Over the last several years, a group of Gulf Coast shipyards led an effort with EPA to develop best management practices for stormwater.¹⁸ Additionally, many shipyards on the West Coast capture and treat stormwater before discharging it.

Case Study: Eliminating Stormwater Discharges at Todd Pacific Shipyard

Before Todd Pacific Shipyard Corporation could effectively remediate the contaminated sediment that had accumulated around its facility over the past century, the shipyard needed to prevent future releases of contaminants to the water. Located on Harbor Island in Seattle, WA, Todd Pacific's various construction, repair, and maintenance operations take place on a 10.5-acre paved industrial yard. In the past, rainwater that fell on the pavement was discharged to surrounding waters via outfalls and served as a major source of sediment contamination. To prevent future contamination, the company has implemented a system that collects the stormwater runoff from the primary yard pavement and discharges the water into the sewer so it can be treated at the Seattle Public Utilities treatment plant. Key design features of this system include the following elements:

- Industrial runoff from the paved yard is channeled through catch basin sumps for solids removal and then passes through a second-stage treatment method for additional solids removal as well as oil and grease separation.
- Runoff from roofs and the employee parking lot is separated from the industrial runoff and discharged through existing outfalls.
- New 450,000-gallon detention tanks are large enough to handle runoff from a 10-year storm event.
- Discharges from the detention tanks to the Seattle Public Utilities sewer are metered so as not to exceed the capacity of the sanitary system.

This new stormwater control system at Todd Pacific exceeds regulatory requirements and eliminates all routine industrial stormwater discharges to adjacent waters.¹⁹

